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## Sideeffect GamePlan: Development of an alcohol and other drug serious game for high school students using a systematic and iterative user-centred game development framework

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### ABSTRACT

Serious games have shown to be effective in improving motivation to learn, knowledge and retention, thus are being increasingly used for alcohol and other drug (AOD) education. This paper outlines the development of an online AOD serious game for in-class use by Australian secondary school teachers for students in Years 9–10. Adapted from Edwards et al. (2018), the seven-step *systematic and iterative user-centred development framework* included: (1) Forming an expert multidisciplinary design team, (2) Defining the problem and establishing user preferences, (3) Incorporating the evidence base, (4) Serious game design, (5) Incorporating behavioural and psychological theory, (6) Developing a logic model and investigating causal pathways, and (7) User testing. High school students ( $n = 8$ ), health and physical education teachers ( $n = 7$ ), and parents ( $n = 8$ ) were engaged throughout different stages of the development process to inform development and provide feedback on considerations for promoting engagement, acceptability, and usability of the game amongst both students and teachers. Overall, participants rated game acceptability and usability favourably and would recommend the game for learning about AOD. Constructive feedback and suggestions for improvements from user testing sessions were implemented to form the final version of the game and module. The next step is to test *Sideeffect GamePlan* in a simulated classroom environment before piloting in school settings.

### 1. Introduction

The digital era has greatly affected the amount of digital information adolescents are required to process on a daily basis, the way in which they learn, and learning preferences (Anastasiadis et al., 2018). Due to the rapid advancement of digital technology and ability of digital games to provide engaging and motivating learning experiences for students, there has been a marked increase in the use of serious games in education (Anastasiadis et al., 2018). Serious games can be defined as “computer software that merges a non-entertaining purpose (*serious*) with a video game structure (*game*)” (Djaouti et al., 2011, p. 2). Serious games have shown to be effective in improving knowledge and retention,

engagement and motivation to learn, general problem-solving skills, strategic thinking, and cognitive skills, particularly amongst adolescents (Anastasiadis et al., 2018; Clark et al., 2016; Wouters et al., 2013; Zainuddin et al., 2020).

#### 1.1. Serious games in alcohol and other drug education

There has been a marked increase in the number of serious games being developed for alcohol and other drug (AOD) education in recent years (Duncan et al., 2018; Martinez-Miranda & Espinosa-Curiel, 2022; Rodriguez et al., 2014; Stapinski et al., 2018; Willmott et al., 2019). Although few AOD serious games demonstrate direct reductions in AOD

**Abbreviations:** alcohol and other drugs, (AOD); external advisory group, (EAG); health and physical education, (HPE); randomised controlled trial, (RCT); Social Cognitive Theory, (SCT); Self Determination Theory, (SDT); socioeconomic status, (SES); Theory of Planned Behaviour, (TPB); youth reference group, (YRG).

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use, a 2022 review of AOD serious games reports results of quasi-experimental studies and randomised controlled trials (RCTs) to be generally positive (Martinez-Miranda & Espinosa-Curiel, 2022). For example, increased knowledge of AOD effects and protective behaviour techniques (Yap et al., 2020), increased intentions to drink less and drinking refusal self-efficacy (Hong et al., 2020), and reduced binge drinking among adolescents aged 15–16 years (Jander et al., 2016). All AOD serious games included in the 2022 review were designed with harm reduction or prevention objectives (e.g., reducing risky health behaviours and protective behavioural techniques) and mechanics to facilitate knowledge acquisition (Martinez-Miranda & Espinosa-Curiel, 2022). Harm reduction in the AOD context refers to “public health measures designed to reduce the negative individual or social effects associated with AOD use” (Alcohol and Drug Foundation, 2022; Single, 1995, p. 287) and is focused on the prevention of harm resulting from AOD use, rather than the prevention of AOD use itself. AOD programs focusing on harm reduction and based on social influence approaches are recommended in school-based programs (Alcohol and Drug Foundation, 2020; Meyer & Cahill, 2004), and when incorporated with digital delivery have demonstrated efficacy in increasing AOD knowledge, reducing risky drinking, and reducing weekly alcohol consumption among adolescents (Newton et al., 2010).

In Australia, AOD education is delivered within the Health and Physical Education (HPE) curriculum in secondary schools (Australian Curriculum Assessment and Reporting Authority, 2021, pp. 1–47) providing the ideal opportunity for targeting knowledge and skills related to minimise AOD-related harm (Teesson et al., 2012). Despite the potential of AOD serious games to promote knowledge and reduce AOD-related harm, there are factors that limit their effectiveness in educational settings. Student engagement and the ease of adoption and implementation by schools and teachers have been identified as key factors contributing to the effectiveness of AOD educational programs both generally (Dusenbury et al., 2003; Meyer & Cahill, 2004), and for digital interventions (Stapinski et al., 2018; Vogl et al., 2009, 2012). An evidence-based approach to promoting acceptability, usability, engagement, effectiveness, and adoption of digital interventions is through engaging end-users throughout phases of development (Davis et al., 2018; Jones et al., 2020; Nicholas et al., 2021; Ozer et al., 2020; Pontual Falcão et al., 2018). In a 2020 systematic review investigating methodologies used for serious game design, user-centred design was reported as being a highly beneficial approach, with 67% of methodologies analysed considering the end-user as having a pivotal role during design due to the pedagogical and playful characteristics of serious games (Sandí Delgado & Bazán, 2020).

Beyond a user-centred approach, the quality and effectiveness of serious games developed for educational settings can be enhanced by incorporating evidence-based approaches for serious game design in education settings, further enhanced through the adoption of systematic frameworks outlining theoretical approaches (Arnab et al., 2013; Avila-Pesántez et al., 2017; Krath et al., 2021; Martinez-Miranda & Espinosa-Curiel, 2022). Although co-design and participatory-led approaches have been adopted in AOD serious game development previously (Stapinski et al., 2018), design and development based on systematic frameworks outlining conceptual and theoretical approaches are lacking (Martinez-Miranda & Espinosa-Curiel, 2022).

### 1.2. Systematic and iterative user-centred development framework

Edwards et al. (2018) propose a *systematic and iterative user-centred development framework* for the development of gamified health applications. The seven steps outlined by Edwards et al. (2018) include: (1) Forming an expert multidisciplinary design team, (2) Defining the problem and establishing user preference, (3) Incorporating the evidence base, (4) Integrating gamification, (5) Incorporating behaviour change techniques, (6) Developing a logic model and investigating causal pathways, and (7) User testing (Edwards et al., 2018).

Edwards et al. (2018) report “recent frameworks including our own are designed around guidelines for complex interventions involving a systematic development process with an iterative user-centred approach based on theory and evidence. It is likely that these elements are key for the development of health apps that may be effective at modifying health behaviours” (Edwards et al., 2018, p. 11). Systematic and iterative user-centred approaches based on theory and evidence have been adopted in development of health and educational digital applications targeted at adolescents, with studies reporting high levels of engagement, acceptability, and usability, as well as the potential to improve motivation for health behaviour change and health-related outcomes (Davis et al., 2018, 2021; Ozer et al., 2020; Werner-Seidler et al., 2017, 2019).

A *systematic and iterative user-centred development framework* has yet to be applied to the development of an AOD serious game for adolescents for use in health education classes. Application of this framework may be advantageous for AOD educational intervention designers and researchers, as well as game developers, for several reasons. Beyond engaging end-users throughout phases of development, the framework includes outlining evidence and theoretical models supporting content and game design and development. Further, the framework incorporates a logic model of change, a systematic approach also used in intervention mapping to guide the ‘ingredients’, causal pathways, and stages of intervention-based research (Bartholomew Elderidge et al., 2016). Systematically unpacking and outlining intervention ‘ingredients’ is important for understanding mechanisms of change and evaluating effectiveness and implementation of interventions (Craig et al., 2019). In the context of an AOD serious game for adolescents, developing a logic model of change will assist in identifying key elements that are vital to incorporate in design and development. Identifying key elements will enable researchers and game developers to target potential mechanisms of change and increase the effectiveness of AOD serious games in improving knowledge and reducing AOD-related harm.

### 1.3. The present study

This paper outlines the phases of development of *Sideeffect GamePlan*, an AOD serious game module developed for use by Australian secondary school teachers with students in Years 9 and 10 (aged 14–16 years). Below we outline the application of a *systematic and iterative user-centred approach* (Edwards et al., 2018) to the development of an AOD serious game.

## 2. Material, methods, and results

Ethics approval was granted by the Edith Cowan University Human Research Ethics Committee (2020-01560-LOMBARDI). To prevent duplication of information for each of the phases of development, the methods and results sections are presented together. While the steps outlined below follow methods developed by Edwards et al. (2018), two of the seven steps were adapted to suit the context of serious game development (*Step 4: Serious game design* as opposed to *Integrating gamification*) and behavioural and psychological theories adopted for the context of AOD education (*Step 5: Incorporating behavioural and psychological theory* as opposed to *Adding behaviour change techniques*). The 7-step cycle is outlined in Fig. 1.

### 2.1. Hybrid agile approach to game development

Edwards et al. (2018) adopted principles of Agile development (Flood et al., 2016) for formulation of a gamified health app. The values of an Agile methodology similarly underpinned the development process of this project, with a focus on individuals and interactions, working software, customer (end-user) collaboration, and responding to change (Fowler & Highsmith, 2001). The development team did not adopt a rigid project management methodology, but utilised a hybrid approach

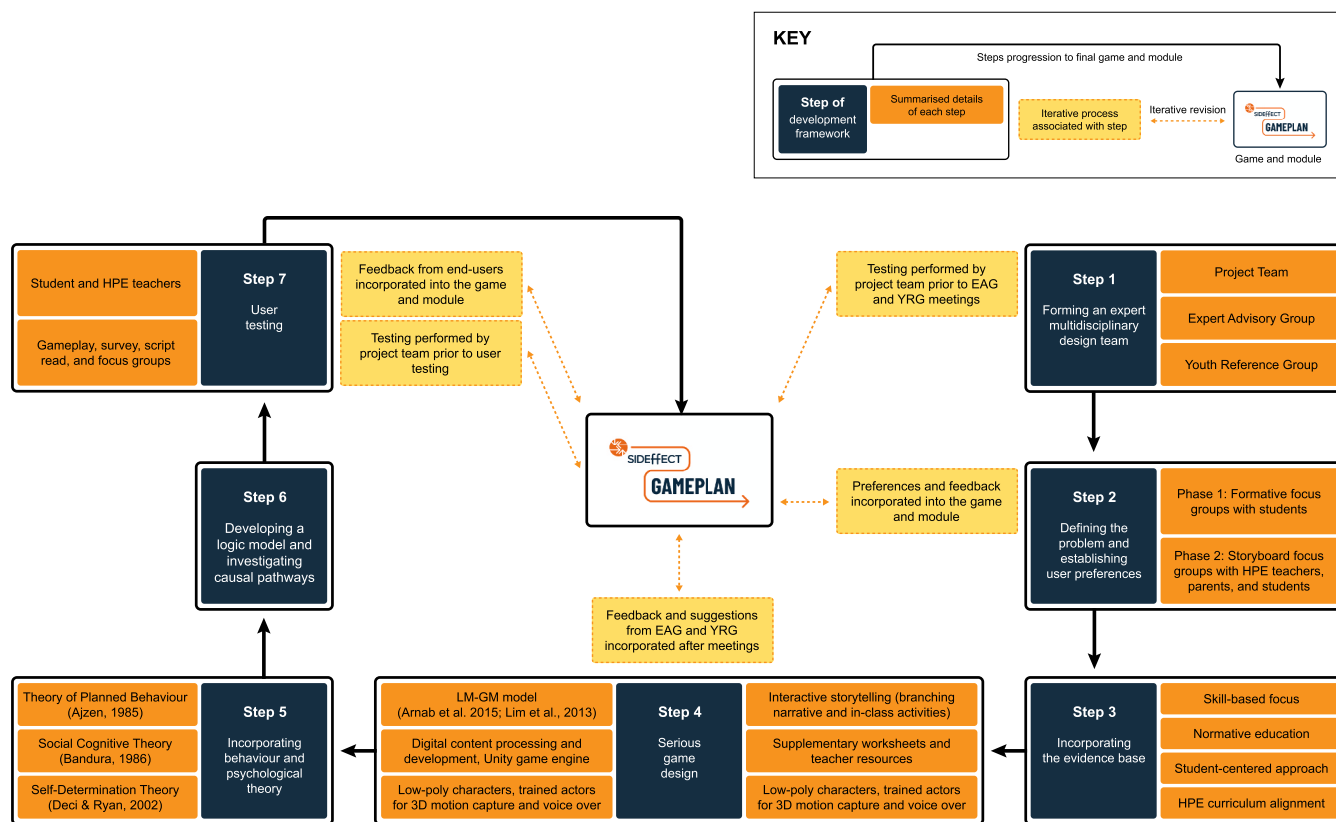


Fig. 1. Steps of the systematic and iterative user-centred development framework (modified from Edwards et al., 2018), summarised details of each step, and key iterative stages. EAG: Expert Advisory Group; YRG: Youth Reference Group; HPE: health and physical education teachers.

with elements of Scrum (Sprints and Scrum meetings), Extreme Programming (Whole Team and Planning Game), and Kanban (Kanban tracking board) (Fowler & Highsmith, 2001; Hezam, 2021, pp. 1–13; Lindstrom & Jeffries, 2003). Iterations occurred throughout the 7-step cycle, key iterative stages are outlined in Fig. 1.

### 2.2. Step 1: Forming an expert multidisciplinary design team

An expert multidisciplinary project team was formed. The project team comprised of researchers with expertise in user-experience, AOD treatment and tertiary education, secondary health and physical education, psychology, game theory and developers with expertise in game design, Unity game development, scripting, and 3D motion capture. The development team (LH, LB, JW) and research lead (JN) met weekly. Throughout data collection and analysis the research team (JN, SH, BM, SB, JS, IM, HB) met on a regular basis, with the research lead (JN) acting being primarily responsible for sharing of information across the development and research team.

In addition to the project team, two additional groups were formed to contribute to the design process.

- (1) An external advisory group (EAG) comprising of five members was formed prior to commencing formative research. Group members had internationally recognised expertise in AOD research and policy development, AOD community education, AOD community support, digital methods and gamification in education, and game design and serious game theory for education. The project team consulted with the EAG four times over the project period from July 2020 to August 2021. The focus of the meetings included: interpretation of literature, aiding in interpretation of focus group data and contextualisation of results in

the development of a serious game, reviewing development of the serious game, and providing guidance on the delivery of AOD education modules in high schools. Discussions contributed to ensuring the project team were well-positioned to ensure equitable and accessible delivery and presentation of module content for end-users (i.e. high school students) (Thornton et al., 2018).

- (2) A youth reference group (YRG) comprising four adolescents aged 13–19 years (2 female, 2 male) was consulted to provide advice and feedback on research procedures and documents. Following an introduction to the project and a summary of findings from focus groups, the YRG provided feedback on the time taken to complete game play-through and script read-through, readability of scripts and surveys, along with other considerations for the testing session with students. Feedback was implemented to improve readability and acceptability of research materials for adolescents. In addition, technical issues (e.g., bugs) that were reported in YRG sessions were fixed prior to user-testing sessions.

### 2.3. Step 2: Defining the problem and establishing user preferences

Despite some AOD digital intervention studies engaging end-users during formative phases of development (Edwards et al., 2018; Stapinski et al., 2018) approaches exploring user-preferences among students are limited and factors promoting student engagement (particularly in males) are not well understood (Stapinski et al., 2018; Vogl et al., 2009). Further, implementation of evidence-based AOD education within schools is reportedly low and feasibility of implementation is moderated by factors such as classroom characteristics and context (Stapinski et al., 2017). With these factors in mind, several formative phases were conducted to gain an understanding of factors to promote student engagement, adoption, and implementation of an AOD

serious game within HPE classes.

### 2.3.1. Phase 1: Formative focus groups with students

Focus groups were conducted with 36 high school students to explore factors to promote learning and engagement in an AOD serious game. While a thorough presentation and interpretation of the results of these focus group data have been published elsewhere (Nicholas et al., 2022), globally these data suggested that incorporating meaningful realistic scenarios, relatable characters, relevant information, and practical skills increased chances of promoting student engagement with AOD educational content. Students expressed desire to learn more about the risks of using more common substances (such as alcohol and cannabis), practical harm reduction strategies, and ways to overcome social pressure without feeling judgement from peers. Game design preferences included incorporating social elements and decision-making opportunities. Setting the game at a house party and incorporating harm reduction strategies (e.g., identifying adverse reactions, when to call an ambulance) were also recommended as these were identified as being realistic and relevant to adolescents.

### 2.3.2. Phase 2: Storyboard focus groups with Health and Physical Education (HPE) teachers, parents of high school students, and high school students

A second phase of three separate focus groups was conducted with (1) secondary school HPE teachers ( $n = 7$ ), (2) parents of high-school aged children ( $n = 8$ ), and (3) high school students ( $n = 6$ ). There was no relationship between these groups (i.e., no parents or teachers of students). This phase included obtaining feedback on a storyboard outlining the narrative structure of educational modules, storylines, AOD content focus (including harm reduction strategies), and aesthetic examples of scene and character models (Fig. 2). In addition, teachers were asked about the logistical practicalities of delivering health education in modern day schools (e.g., access to technology, timetabling) along with other facilitators and barriers to adoption and implementation of an AOD serious game module in Australian secondary schools.

Participants were recruited via an external recruitment company with a database of approximately 40,000 people from amongst the general population in Western Australia. Participant demographics are included in Table 1. Participants were remunerated for their time to the value of \$70 AUD for students and \$90 AUD for teachers and parents. Prior written consent was obtained from all participants and parental consent was also obtained for the adolescent cohort.

Focus groups took place in December 2020 at Edith Cowan University, Mount Lawley and were facilitated by three members of the project team (JN and JW or LH). JN has experience in conducting qualitative user-experience research, JW and LH have experience in game design and development, and user-experience research. Team members conducting focus groups were not previously known to focus group participants.

Focus groups were audio recorded and transcribed verbatim. Following principles of reflexive thematic analysis (Braun & Clarke, 2022) transcripts were coded independently by SH and HB using NVivo 12 qualitative data analysis Software (QSR International Pty Ltd).

Adopting a ‘critical friends’ approach (Smith & McGannon, 2017), themes and sub-themes were refined in an iterative manner until common agreement was reached (Braun & Clarke, 2022; Smith & McGannon, 2017). Results from second phase focus groups are presented in Table 2 along with key considerations and preferences that were incorporated into the game and module.

### 2.4. Step 3: Incorporating the evidence base

The project team performed an extensive literature search and synthesis of evidence for best practices in AOD education. A summary of the literature is provided below.

#### 2.4.1. Skill-based focus

Effective AOD education includes the development of skills and attitudes that can help to keep young people safer (Debenham et al., 2020). It is imperative that AOD education not only provides accurate information and dispels myths about drug use, but also incorporates meaningful learning activities that focus on real life contexts and challenges, and be based in the theoretical understandings of adolescent behaviour (Meyer & Cahill, 2004).

#### 2.4.2. Normative education

While normative beliefs, peer pressure, and poor resistance skills may be reasons for young people to use AOD, young people may have positive expectancies around AOD use, and may simply seek to alter their conscious state (Skager, 2009). Furthermore, their positive experiences with AOD and the positive experiences of others, where harm was not experienced, mean that young people are likely to experiment with AOD use, despite (or even because of) recommendations for abstinence (Skager, 2009). The importance of education focusing on harm reduction is therefore imperative.

#### 2.4.3. Student-centred approach

It is recommended that AOD education is student-centred, and uses interactive strategies to develop students’ knowledge, skills, attitudes, and values (Meyer & Cahill, 2004). There are three common intervention approaches: universal (delivered to all), selective (delivered only to those seen to be at risk), and indicated (delivered only to those who already have problematic behaviours) (Newton et al., 2017). Universal approaches are favoured, as they reduce stigmatisation of young people singled out for selective or indicative interventions. The most successful universal approaches usually have a harm minimisation goal, are underpinned by a social influence approach and are implemented with high fidelity (Newton et al., 2017). Effective programs use highly interactive pedagogies, where students are engaged in problem solving, and critical thinking. Such programs incorporate messages that indicate to young people that risky use of drugs and alcohol are not the societal norm and allow students to experiment with a range of value clarification skills, while experiencing competing desires and influences. Such an approach acknowledges that peer pressure is not something to be protected from, but rather, part of the complex landscape where young people make decisions about AOD use.

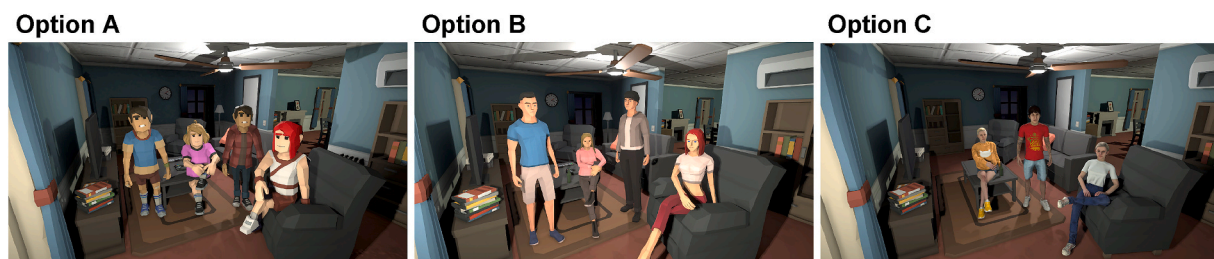


Fig. 2. Character art styles presented to participants for feedback in focus groups.

**Table 1**  
Focus group participant demographics.

Step	Cohort	Sample size (n)	Gender	Age (years) Mean (range)	School type	Teaching experience (years) Mean (range)	Number of children Mean (range)	Age of children (years) Mean (range)
Step 2 Phase 2	Adolescents	6	3 female, 3 female	16.6 (16–17)	4 public, 2 private	–	–	–
	Teachers	7	1 female, 6 male	41.1 (31–59)	6 public, 1 private	14.56 (4–38)	–	–
	Parents	8	4 female, 4 male	51.1 (43–65)	5 public, 3 private	–	2.9 (2–6)	19.1 (14–33)
Step 7 User testing	Adolescents	6	3 female, 3 male	16.5 (16–17)	5 public, 1 private	–	–	–
	Teachers	7	1 female, 6 male	41.1 (31–59)	6 public, 1 private	14.56 (4–38)	–	–

2.4.4. HPE curriculum alignment

AOD education is best initiated before young people start to use drugs and patterns become established (Midford et al., 2002). In order to achieve long-term change, AOD education is best taught in the context of a sequential, developmentally appropriate school health curriculum (Midford et al., 2002) and should be taught in a developmentally appropriate and ongoing manner (Meyer & Cahill, 2004). In other words, increases in the complexity of AOD education should be consistent with the increasing complexity of issues as young people age.

2.4.5. Incorporating the evidence into Sideffect GamePlan

Sideffect GamePlan was designed as a 6-lesson module, aligning with previously reported intervention session range (4–12 sessions) for AOD education program effectiveness (Champion et al., 2013). Sideffect GamePlan was developed in close alignment with the Year 9 and 10 Australian Curriculum for HPE (Version 8.4 (ACARA, 2018, pp. 1–34); and guided by principles of effective AOD education including a focus on harm reduction, real-life scenarios, resistance skills whilst maintaining social standing, and student-centred activities (Champion et al., 2013; Drugs and Crime, 2015; Lee et al., 2016; Meyer & Cahill, 2004; Midford et al., 2002; United Nations Office on; Vogl et al., 2009; Vogl et al., 2012). Examples of specific materials used to guide content development included the Alcohol and Drug Foundation “Reducing the risk” resources (Alcohol and Drug Foundation, 2022) and the Principles for School Drug Education (Meyer & Cahill, 2004). An outline of harm reductions strategies and key AOD topics that were incorporated into the game and lessons are provided in Table 3.

2.5. Step 4: Serious game design

Edwards et al. (2018) highlighted a lack of empirical guidance for gamification taxonomies and frameworks and therefore adopted seven gamifications strategies to optimise motivation among users (Cugelman, 2013). As Sideffect GamePlan was developed from a blank canvas rather than gamifying an existing concept (Ferrara, 2013), Step 4 of the original framework proposed by Edwards et al. (2018) was modified from gamification to serious game design.

2.5.1. Serious game framework

There are numerous theories, frameworks, models, patterns, and guides provided by professionals and researchers on designing and analysing serious games. Adopting a serious game framework in the development of serious games allows researchers to map game mechanics to intended outcomes, thereby giving insight to potential mechanisms enabling change (Arnab et al., 2015; Lim et al., 2013). A 2022 review of AOD serious games for youth found that most studies only specified the platform in which the game could be deployed (e.g., web or mobile) rather than reporting computational techniques and serious game approaches that were adopted (Martinez-Miranda & Espinosa-Curiel, 2022). While a systematic review of computerised serious AOD games reported the potential for serious educational games

to improve knowledge, attitudes and behaviour towards AOD, none reported the use of a serious game framework or model to guide development (Rodriguez et al., 2014). As adoption and reporting of serious game models in AOD serious games is limited, consideration of existing models leveraged in other health contexts was required.

The learning mechanics and game mechanics (LM-GM) model (Arnab et al., 2015; Lim et al., 2013) was chosen due to its strong focus on mapping how learning outcomes are supported through use of game mechanics (Arnab et al., 2015). The LM-GM model has been used as a framework for mathematical (Cecotti & Callaghan, 2022) and engineering education (Callaghan et al., 2016) with goals of developing critical-thinking skills, increasing student engagement and retention, and a pedagogically sound immersive learning experience. The model has also been adopted in health education for development of a pedagogically-driven serious game to support personal relationships and sex education (Arnab et al., 2013). Reported findings from a small cluster RCT found high student engagement with the game and associated classroom discussions, and demonstrated improved understanding of personal risks and consequences associated with coercion (Arnab et al., 2013).

The LM-GM model is not prescriptive and allows freedom for game designers and educators to map utilisation of different mechanics to achieve desired learning outcomes (Arnab et al., 2015). Steps for applying the LM-GM model are to (1) identify desired learning and game mechanics to be used in game scenarios, and (2) create a concept map detailing the dynamic interaction of these mechanics during gameplay (Arnab et al., 2015).

The project team identified learning and game mechanics to be used for game design and continued to consult on and adjust these over the course of game development. The relationship between game and learning mechanics and how they are implemented in-game are described in Table 4. The game flow map in Fig. 3 depicts their use during the structured game experience.

2.5.2. Design features and mechanics

An Interactive Storytelling format was selected for the game and module design, utilising a branching narrative with associated in-class activities. Narrative approaches are well-suited to inform complex health topics (Miller-Day & Hecht, 2014) as they have the ability to overcome resistance towards health behaviours, engage less involved audiences, and deliver complex information in an understandable manner (Hopfer & Clippard, 2011). Narrative approaches have been shown to be effective in promoting drug knowledge among adolescents (Epstein et al., 2009), and when combined with digital games provide a high potential for supporting education of various school subjects (Breien & Wasson, 2022). When incorporating narrative approaches in AOD lessons, the quality of narrative delivered by teachers is directly associated with student engagement (Miller-Day et al., 2015). Embedding narrative into a serious game allows for consistent story delivery, thereby promoting fidelity and eliminating the need for training teachers in effective storytelling. Adopting a narrative design supports

**Table 2**  
Second phase (2.3.2. Phase 2) focus group results: students, teachers, and parents.

Themes	Subthemes	Supporting quotes	Key considerations and preferences incorporated into the game and module
AOD learning	Harm reduction strategies	<p>“I like the idea of the harm minimisation [reduction], looking for the risky behaviours, opening up that discussion of how to keep yourself safe. So, if people are doing things you don't want to be doing, how you can avoid it, avoid it without looking like you're being socially awkward ... or what you can say so you don't say 'no' because so many kids don't want to say 'no'.” (Parent)</p> <p>“I think the option where the girl could stick with her decision instead of making up an excuse, I think that's an important thing. People aren't really told, 'It's okay to do what you want to do', and I think that was really good option.” (Student)</p>	Identifying and discussing harm reduction strategies, incorporating refusal skills and assertive responses into storylines.
	Discussion points, and suggested worksheet and classroom activities	<p>“I think summing up [harm reduction strategies observed in the game] is good because I know in class, if you just look at a screen, you just doze off, but if it's at the end, kids might get blindsided with it if they've zoned out the whole time.” (Student)</p> <p>“If you have a worksheet and there's a bunch of questions and you're pausing it [video] as you're going sort of thing and they have to take notes down, you get to the end and they actually know what the video was about as opposed to if I was to just play it and they're just sort of like, 'All right, cool.' So definitely, if they have a worksheet, adding that option to help go through that would be [great].” (Teacher)</p> <p>“[completing a worksheet] holds them accountable.” (Teacher)</p>	Worksheet activities including mini quizzes and discussions to promote concentration and retention of information.
	Gamified experience enhancing learning	<p>“And this [game] is better than – [be]cause usually when you do this stuff at school, you just get a scenario on a piece of paper and you just had to talk about it, like ... just a piece of paper, and then you just talk about it, but this is better [be]cause you can actually do it. You can visualise characters and stuff.” (Student)</p> <p>“I think it would just help you understand more, because I know in health classes, we'll just get overloaded with information and we just wouldn't absorb it all, whereas this is something where everyone's engaged.” (Student)</p> <p>“[I would choose this format over other delivery methods because it's] “interactive and engaging. So we generally find that students will be instantly engaged in it, like even with the Click2Save that I did, I was really surprised at how they like ... That's just first aid, but they were like really engaged with it.” (Teacher)</p>	<p>Serious game perceived as more engaging and interesting than traditional methods of leaning about AOD.</p> <p>Teachers voiced interest in adopting the game as they perceived it to be engaging and interactive.</p>
	Negative (exogenous) consequences from game	<p>“I think they're already exposed.” (Parent)</p> <p>“It's so exposed everywhere. I really don't think there would be [any concerns about exposing students to this content?].” (Parent)</p>	Participants didn't perceive the game to have negative consequences on young people i. e., encouraging AOD use.
Relatability, believability, and relevance	Cocaine use not relevant, better to include pills, change AOD terminology	<p>“Yeah, and the past cocaine use, in Australia, it's not feasible. I don't think it's feasible. I think for the age group you're aiming for as well, cocaine is not a huge thing .... And it's not something that I think a lot of them would identify with.” (Parent)</p> <p>“And tablets, the pills are just out there everywhere.” (Parent)</p> <p>“The only thing that I found, that might just be me not knowing it, is I've never had anyone say eccies before. So I'm not sure if that's just something I've not come across or if it's not very common thing people say .... Caps – is a very common one.” (Student)</p>	Believability of other forms of substance use by characters was discussed. Terminology was adjusted to be more generalised and to avoid confusion over regional variations.
	Relatability of characters and relationships	<p>“I feel like stereotypes are probably easier to relate to in a way because you can always fit yourself to one type of person, but not overly stereotypical to the point where this isn't a person that you'd see in real life and stuff like that.” (Student)</p> <p>“[Age] 17 and 18 [years] is perfect, because that's what happened at the leavers, isn't it? Some of the kids there are 17 and some of the kids are 18.” (Parent)</p> <p>“I was thinking that the one with Sadie and Mackenzie, Mackenzie could be like – to Sadie, 'Oh, have some more fun and have more drinks,' and sort of, tell her to 'let go a bit' [be]cause they're friends and I feel like that's something that friends would do, like, 'Oh come on, have fun' and all of that.” (Student)</p>	<p>Participants confirmed importance of including a range of characters and including stereotypes.</p> <p>Age of characters is ideal and realistic.</p> <p>Suggestion to incorporate social pressure into friendship dynamics.</p>
	Decision-making	<p>“Also on decision making, I definitely think it's a good idea to not have a very clear right choice or wrong choice because some students may just think, 'I'll just make all the wrong choices for fun', and then they won't really take it seriously. You should have to put thought into the choices that you make.” (Student)</p> <p>“When it's a game, they can [make bad decisions] without danger, and they'll definitely do it.” (Parent)</p>	Choices available at decision branches were not framed as being 'right' or 'wrong', rather the content of each branch was designed to reveal different insights and character behaviours within the story while maintaining the primary lesson themes and storyline outcomes.

(continued on next page)



Table 2 (continued)

Themes	Subthemes	Supporting quotes	Key considerations and preferences incorporated into the game and module
	Incorporate consequences of AOD use that are relevant to adolescents	<p>“I’m sure something we [teachers] all speak about is the consequences of the drug conviction sort of thing with regards to things such as working FIFO [fly-in-fly-out], international travel, all that sort of stuff .... So you’ve got to make it really related to them to say, ‘Okay, in a few years’ time, this is –’ and not too distant, so it can be four or five years, this could be a serious consequence for you, or if you’ve got an apprenticeship and then you basically get a DUI [driving under the influence] or a drug conviction or something like that, you can just “bang” and you just go out that. That’s reality.” (Teacher)</p> <p>“I think putting consequences into it, like embedding consequences heavily into the game ... if you drink drive and you get done for DUI then you then can’t get your license, then you also possibly might not be able to travel outside of Australia because you’ve got a criminal record, so things like that. I think just showing that making a small bad choice can still give you consequences and the worst, your choice is the worst the consequences can end up going.” (Teacher)</p>	Relevant and heavier negative consequences of AOD use were reviewed and modified. For example, being kicked off the footy team was added into storylines for Jonno and Nathan.
	Incorporate real life stories	<p>“One thing you said earlier about linking it back to real-world characters and things, if you’re going do something like that, if you put a list of people who have died from a particular drug overdose that was featured in their storyline, that would be shocking to them. It doesn’t have to do anything, but instead put the names of people they recognise.” (Parent)</p> <p>“I think [having examples of real consequences experienced by famous people] is good ... I think [be]cause it tells you the end of that story, ‘this is where it’s going to lead, that person is dead, that person had a car accident, that person is in a rehab.’ These are the real [consequences or outcomes of harmful AOD use].” (Parent)</p>	Suggestion to incorporate real-life stories in or at the end of the game, including an <i>in-memorandum</i> section.
	Language and voice acting	<p>“I think different characters should have different ways they talk. If it’s – which one was the dodgy one? [Nathan] – he should talk a bit less formal than [Josh] kind of thing, just to reflect their character more.” (Student)</p> <p>“I think the language used in it is really good in it. It seems quite natural, everything there [in the Sadie-Mackenzie script].” (Student)</p>	Variations in language and terminology used across characters to differentiate them.
	Arts style (graphics) (see Fig. 2)	<p>“Personally, I like [option B] the most, I think it is [good] a middle ground.” (Student)</p> <p>“[Option B] is still realistic in a way, it’s what you would expect more, I think. You wouldn’t expect it to be super realistic. And it’s nice to look at.” (Student)</p>	Students indicated preference for Option B art style.
Promoting adoption by teachers	Time available for AOD education	<p>“For us, it’s generally one term so 10 weeks, 10 lessons”. (Teacher)</p> <p>“We only have it once a week .... And then they’ll have one term of alcohol, one term of drugs maybe but probably not in the same year”. (Teacher)</p>	The reported average class duration was 60 min, with one teacher suggesting no more than 45 min of game or module content to ensure time for set up and other administrative tasks.
	Internet and device limitations, game access, user accounts, login restrictions	<p>“We wouldn’t be able to do it individually either [be]cause we don’t have enough computers.” (Teacher)</p> <p>“Our bandwidth is a massive issue.” (Teacher)</p> <p>“I suppose that’s when the interactive up on the board would be ideal, [be]cause the teachers are going to have a device all the time, generally. So then it comes up on the board and regardless of if your class can access it or not – you can still use it ‘cause it’s up on board and you can use it as a teaching tool to probably get more gameplay out of it I think than trying to pitch it to every kid using it individually.” (Teacher)</p>	Teachers identified and described several suggestions for overcoming barriers and promoting the adoption of an online AOD education game in schools and with teachers. A suggestion for overcoming barriers of limited number of devices, insufficient bandwidth, and individual student access included delivering the game using a single-screen teacher-led classroom approach whereby the game is played through, and projected from, the teacher’s device.
	Accessibility User-friendliness, professional development, and curriculum alignment	<p>“It’s good to have the text [subtitles] there too just for literacy and tracking.” (Teacher)</p> <p>“I’m one of those old guys so just make it user-friendly. If it’s not user-friendly, I’ll flick/forget it in a heartbeat, simple as that”. (Teacher)</p> <p>“PD sessions for the teachers is a fantastic idea.” (Teacher)</p> <p>“If it’s linked to the points in the curriculum then it ticks those boxes as well for the teachers to say, ‘Okay, you’ve covered off this point, this point, this point’. They will then see the value and going, ‘Okay, so if I teach this section or whatever, it’s the one, two or three lessons,’ they think back to it and technically have done 40% of my content [in] only three lessons.” (Teacher)</p>	Subtitles remained in the game. Teachers described user-friendliness being an important consideration for adoption in HPE teachers, particularly for promoting uptake among less technologically advanced teachers. Professional development and curriculum alignment were also highlighted as ways to promote buy-in from teachers.

the use of realistic and relevant scenarios and storylines, and relatable characters which have been identified as engaging factors for student users (Nicholas et al., 2022; Rose & Unni, 2020). Further, narrative design supports the delivery of content and educational approaches based on principles of social learning and modelling behaviour (Miller-Day & Hecht, 2014; Ozer et al., 2020; Shin et al., 2018).

The *Sideeffect GamePlan* narrative consists of a multilayered story explored by following the choices made by three main characters, each revealing a different perspective of the events leading up to an incident at a house party. Each storyline was used to highlight key messages or themes (Table 3 and Fig. 4).

The branching narrative features a linear overarching structure, with branching and foldback substructures (Carstensdottir et al., 2019). The linear overarching structure connects the experiences of the three characters using a frame story format, with the house party incident presented first to form the magic circle (i.e., setup of the game's reality (Salen & Zimmerman, 2003) that prepares students to engage with the experience, and provides context for the game choices and in-class activities that follow (Kili & Lainema, 2008). Each character's story is divided into three acts, with a progression by choice mechanic (Carstensdottir et al., 2019) occurring at branch points throughout, and the foldback substructure used to return to the main storyline. The branch points provide students with a choice through selection of the character response to key moments to give focus to the intent and implication of decisions (Carstensdottir et al., 2019), and to enhance engagement with and provide a sense of participation in the narrative (Fendt et al., 2012; Vosmeer & Schouten, 2014) (see Fig. 5 example). The content of each branch was designed to depict different content and character behaviours within the story while maintaining primary lesson themes. Content duration for simultaneous branches was equal ensuring timing was consistent and gameplay fitted within a standard lesson.

Low-poly characters (Fig. 2b) and surrounding environments (Fig. 6c) were incorporated to ensure data size of the final game could be minimised to allow for hosting and streaming entirely online while also providing an appealing aesthetic for the student audience. A key element for enhancing relatability of characters through narrative scripts was to engage trained young actors to perform all character movements using 3D motion capture in addition to voice over tracks for each of the speaking characters' lines (Hyderabad et al., 2008; Swartout et al., 2001). Development and recording of content in this fashion ensured character movement, behaviours and actions provided a relatable experience for students. Fig. 6 depicts the motion capture process.

### 2.5.3. Digital content processing and development

Content compilation involved an extensive pipeline involving 3D motion capture and voice data processing and synchronisation with facial expressions, the virtual environment, subtitles, and background music. The project development team undertook extensive iterative bug testing and evaluation of final versions of digital content (see Fig. 1). Resulting content represents over 90 min of branching narrative scenes embedded within an intuitive user interface accessible through both web-based and desktop systems. Fig. 7 depicts (a) the timeline for a single scene in the *Unity* game engine, (b) the user interface main screen and (c) final game content scenes.

### 2.5.4. Supplementary worksheets and teacher resources

In conjunction with digital content development, a series of supplementary student worksheets and teacher guides were developed to guide student engagement with narrative content and provide a persistent resource for teachers and students across lessons including prescribed activities between pieces of gameplay. Each worksheet was divided into sections and aligned with four task themes including information about harm reduction, in-game activities (tasking students with locating pieces of information during gameplay), reflection activities (tasking students to individually reflect on the gameplay to discern a strategy or answer a question), and classroom activities (allowing

teachers to facilitate verbal shared discussions across the class based on individual student inputs from reflection activities). Interactive classroom discussions were incorporated to promote sharing of ideas and reinforce core learning. These included student-centred activities focusing on applying concepts from the game to personal contexts (Meyer & Cahill, 2004; Nicholas et al., 2022; United Nations Office on Drugs and Crime, 2015). The worksheet structure was designed to be purposefully consistent across all six lessons for continuity. Teacher versions of the worksheet provide introductory considerations for accessing the digital narrative content, in addition to recommended lesson timings. Teacher guides depict the same identical information as student worksheets (allowing teachers to keep track and view what students are viewing at all times throughout a lesson), with the addition of discussion points and notes teachers have the option to leverage to facilitate discussion and provide contextual information. Both student worksheets and teacher guides underwent stringent testing and refinement prior to finalisation (see Step 7).

Individual activities were accompanied with prescribed timings, combining with associated gameplay to reach a set lesson duration of 45-min, but were designed to be flexible allowing teachers to extend classroom discussions for longer class times. A curriculum mapping document aligning the game and worksheets to the Year 9 and 10 Australian Curriculum for HPE (Version 8.4 (ACARA, 2018, pp. 1–34);) was also developed as a resource for teachers to more readily understand alignment of *Sideeffect GamePlan*'s learning objectives with Australian HPE curriculum.

### 2.6. Step 5: Incorporating behavioural and psychological theory

Edwards et al. (2018) adopted and mapped specific Behaviour Change Techniques (BCT) from Michie's BCT Taxonomy (Michie et al., 2013) into development of their smoking cessation app as it focused on changing existing habits (e.g., smoking). As the focus of the current work was to develop a serious game to promote AOD learning and harm reduction in a classroom environment, not changing existing behaviour, we utilised psychological theories suited to education outcomes rather than BCTs (Martinez-Miranda & Espinosa-Curiel, 2022).

Development of the game and supplementary workbook resources were informed by the Theory of Planned Behaviour (TPB), Social Cognitive Theory (SCT), and Self-Determination Theory (SDT). The TPB focuses on improving attitudes, perceived behavioural control, and subjective norms regarding a healthy behaviour given these increase intention towards adoption of the health behaviour (Ajzen, 1985). The TPB has been used extensively in the development and implementation of a wide range of effective health behaviour interventions (Murphy et al., 2021; Steinmetz et al., 2016), and in AOD serious game design (Martinez-Miranda & Espinosa-Curiel, 2022). Social Cognitive Theory (SCT) consists of three important components, including behavioural capability (ability to perform a behaviour through essential knowledge and skills), observational learning (model behaviours observed through others), and self-efficacy (confidence in one's ability to perform a behaviour) (Bandura, 1986). SCT is suited to AOD serious games with prevention objectives as it enables opportunities for students to observe the consequences of their actions in realistic scenarios (i.e., vicarious learning) (Martinez-Miranda & Espinosa-Curiel, 2022). The TPB and SCT were selected as respective elements aligned closely with project goals of improving AOD knowledge and skills, enhancing self-efficacy to adopt harm reduction strategies and make good decisions about health, and reducing AOD-related harm and intention towards use. Further, AOD education programs targeting self-efficacy, and that adopt social learning or social cognitive principles, have been shown to be effective in reducing AOD use (Champion et al., 2013; Spoth et al., 2008). Finally, Self-Determination Theory (SDT) focuses on the degree to which an individual's behaviour is self-motivated and self-determined (Deci & Ryan, 2002). According to SDT, motivation and behaviour hinges on the satisfaction of three basic needs: (1) autonomy: referring to having a

**Table 3**  
 Incorporating the evidence-base: storyline themes, harm reduction strategies, and key learning topics within each lesson.

Main character storyline	Themes	Lesson	Harm reduction strategies, key learning topics
<b>Josh</b> Party host, sporty, kind, helpful	Introduction to harm reduction, looking after friends in need, de-escalation and first aid	Lesson 1	Space your alcoholic drinks with non-alcoholic drinks Eat food before and/or while drinking alcohol Keep track of how much alcohol you are drinking Stay hydrated by drinking water Avoid mixing alcohol and other drugs Avoid drinking alcohol and/or using other drugs with people you don't know or trust
		Lesson 1A	Assertive communication strategies related to alcohol and other drugs (overcoming social pressure and refusal skills) De-escalation strategies when mediating conflict with people under the influence of alcohol or other drugs The importance of calling 000 in unsafe situations
<b>Sadie</b> Wants to have fun without drinking, good relationship with parents	Making a plan with friends, mixing drugs, effects of AOD on the body, conversations with parents	Lesson 2	The value of creating a <i>game plan</i> with friends to match expectations around alcohol and/or other drugs Strategies for keeping track of the amount of alcohol being consumed using <i>Standard Drinks</i> The risks associated with accepting drinks with unknown ingredients
		Lesson 2A	The effects of alcohol on your body Safe versus unsafe activities while drinking The effects of mixing alcohol with stimulants Strategies to support friends who are having an adverse reaction Discussing alcohol and other drug related behaviours with your parents/guardians
<b>Nathan</b> Recovering AOD issues, experiences social consequences, wants to look after friends	Consequences of AOD use, social pressures, help seeking	Lesson 3	Identifying and communicating acceptable alcohol and other drug behaviours Developing a game plan for dealing with unwanted party guests Identifying the warning signs of problems associated with alcohol and/or other drug use Providing support to friends who may be having problems with alcohol and/or other drug use
		Lesson 3A	The dangers of drink spiking and how to protect yourself How different people might respond to alcohol and/or other drugs in different ways A review of harm reduction strategies explored across <i>Sideeffect GamePlan</i>

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sense of freedom when acting out of one’s own values and interests (Deci & Ryan, 2000), (2) competence: feelings of accomplishment and ability to conquer optimal challenges, and (3) relatedness: the desire to have a meaningful connection to others and to feel a sense of belongingness (Deci & Ryan, 1985). Satisfaction of basic psychological needs leads to the development of intrinsic motivation, which is associated with promoting engagement and learning (Adams & Ryan, 2017; Deci & Ryan, 2000) both generally and through gameplay (Ryan et al., 2006). Therefore, satisfaction of basic needs (i.e., autonomy, competence, and relatedness) were targeted in development. Table 5 outlines how elements from the TPB, SCT, and SDT have been embedded in *Sideeffect GamePlan*.

2.7. Step 6: Developing a logic model and investigating causal pathways

In the context of an AOD serious game for adolescents, developing a logic model of change will assist in identifying key elements that are vital to incorporate in design and development. The logic model was designed to understand the relationship between assumptions, resources, activities, output, potential outcomes, and potential impact. Identifying and mapping key elements will enable researchers and game developers to target potential mechanisms of change and increase the effectiveness of AOD serious games in improving knowledge and reducing AOD-related harm. The logic model of change for *Sideeffect GamePlan* outlines: (1) assumptions underlying the program including a needs analysis and rationale for development of an AOD serious game, (2) planned work including resources, theoretical and conceptual models informing design and development, details of the intervention, and user-testing activities, and (3) intended results including outputs, student and teacher outcomes, and impact at student, school,

community, and system levels (Edwards et al., 2018; Kellogg, 2004) (Fig. 8).

2.8. Step 7: User testing

User testing sessions were conducted following development of the game (Edwards et al., 2018). Both HPE teacher and adolescent cohorts from Step 2 (Phase 2) were invited to participate in Step 7 (user testing). All HPE teachers returned for user testing, four of the six adolescents agreed to participate in user testing and an additional two adolescents were recruited to ensure consistency in sample size (see Table 1 for participant demographics).

Sessions commenced with participants playing through targeted sections of Lesson 1, and immediately followed by completion of a 24-item survey including: (1) *Acceptability*: twelve items (Q1 to 12, see Table 6) focusing on engagement, acceptability of game aesthetics and sound effects, and relevance and appropriateness of content, scenarios, and storyline. Similar items have been used to assess other AOD education interventions targeted towards adolescents (Debenham et al., 2020; Newton et al., 2012; Thornton et al., 2018). (2) *Relatability and believability*: two items (Q13 to 14) covering relatability of characters and believability of AOD-related harm reduction strategies included as these factors promote engagement among students (Nicholas et al., 2022). (3) *Usability*: nine items (Q15 to 23) covering ease of use, confidence in using the game and learning derived from the game included from the System Usability Scale (Brooke, 1995). Existing questions were modified replacing the word ‘system’ with ‘game’. For Q1 to 23, participants were asked to rate statements on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). (4) *Recommend the game*: one item (Q24) asking if participants “would recommend the game to others

**Table 4**  
Relationship between game and learning mechanics and how they are embedded in *Sideeffect GamePlan*.

Game Mechanic	Learning Mechanic	Implementation	Usage
Story	Instructional Observation	Character appearance, dialogue and actions are designed to be relatable and diverse to appeal to the target audience.	Gives context in which the player frames their learning of AOD use. Displays a variety of risky behaviours and models harm-reduction strategies to use in the given scenario. Creates a link between the player and the characters.
	Identify Simulation Modelling		
Cascading information	Guidance Instructional	Non-player character animated actions and dialogue and workbook information sections.	Delivers information at appropriate points in a meaningful order to build and advance knowledge as well as leading the players towards discovering the answer to the mystery.
Feedback	Feedback Rewards	Teacher during class activity and on students’ reflection activities in workbook.	Reinforces and acknowledges the message and learning achievements.
Selecting Options	Participation Identify	Choice between two actions. ‘In-game activities’ in the workbook.	Gives the player a greater sense of engagement and ownership of their personal game narrative.
Questions and answers	Action/task		
	Demonstration Participation Question and answer Discover Reflect Ownership Analyse Discuss	Reflection activities and class discussion.	Demonstrates their understanding by engaging with and applying the content. Uses players’ existing knowledge to discover new solutions to the presented scenario.
Behavioural momentum	Repetition	Levels/lessons.	Increases engagement and investment in the narrative.
	Reflect	Reflection and class discussion activities.	
Communal discovery	Action/task	Class discussions with other players.	Shares knowledge with other players.
	Reflect/discuss Feedback	Peers and teacher give feedback on answers.	
Time pressure Collecting information	Instructional	Time limit for responses. Workbook information and story.	Encourages engagement and finishing the content within class time constraints. Displays safe behaviours, actions to reduce risk, and what to do in an emergency or high-risk situation.
	Guidance Discrimination	Ability to choose different options at the branching narrative points.	Applies this learning to the student’s real life through planning activities.
Levels	Repetition	Review the same event from different perspectives. Interactive story.	Builds knowledge and reinforce messages. Encourages replaying content to view different options.

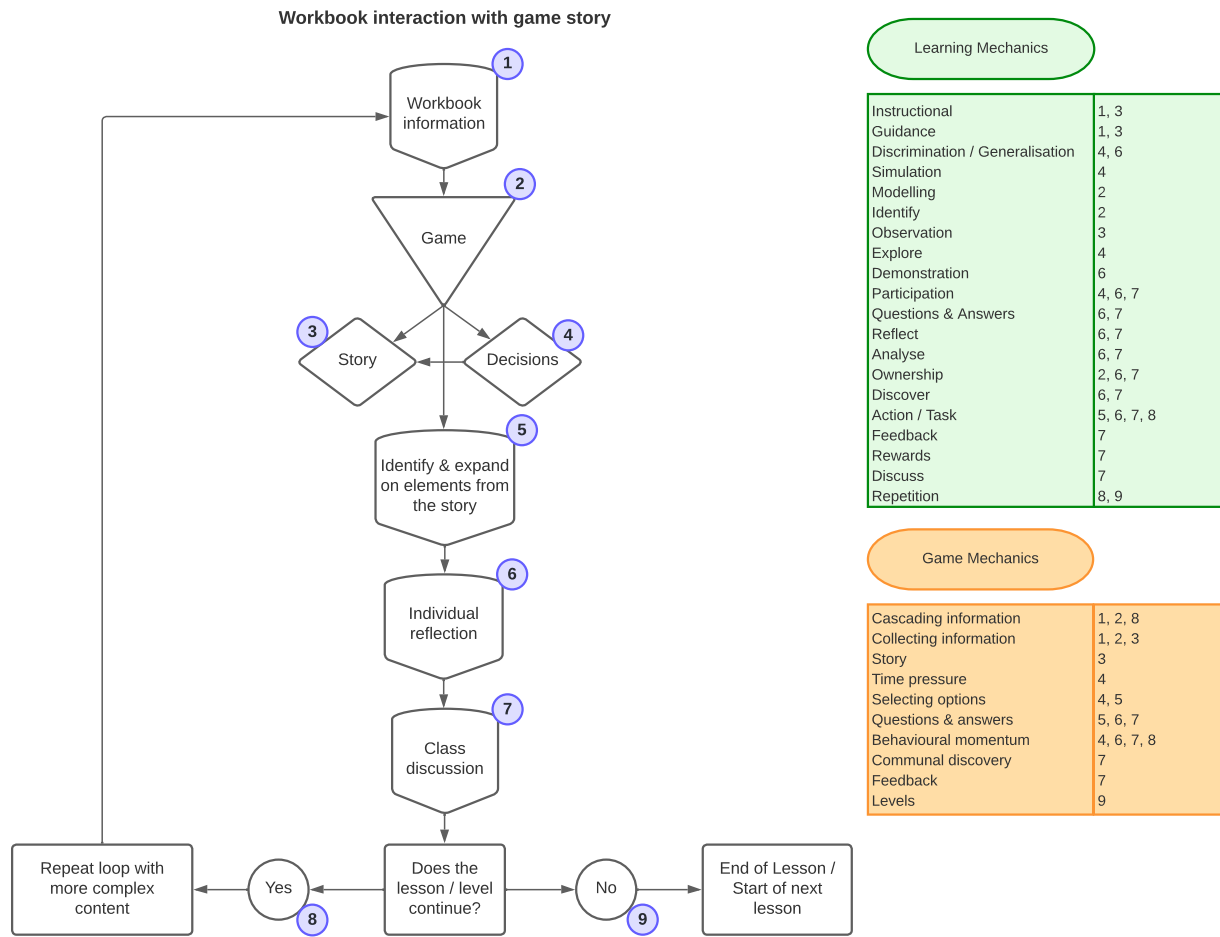


Fig. 3. Concept map relating Sideffect Gameplan learning mechanics to game mechanics.

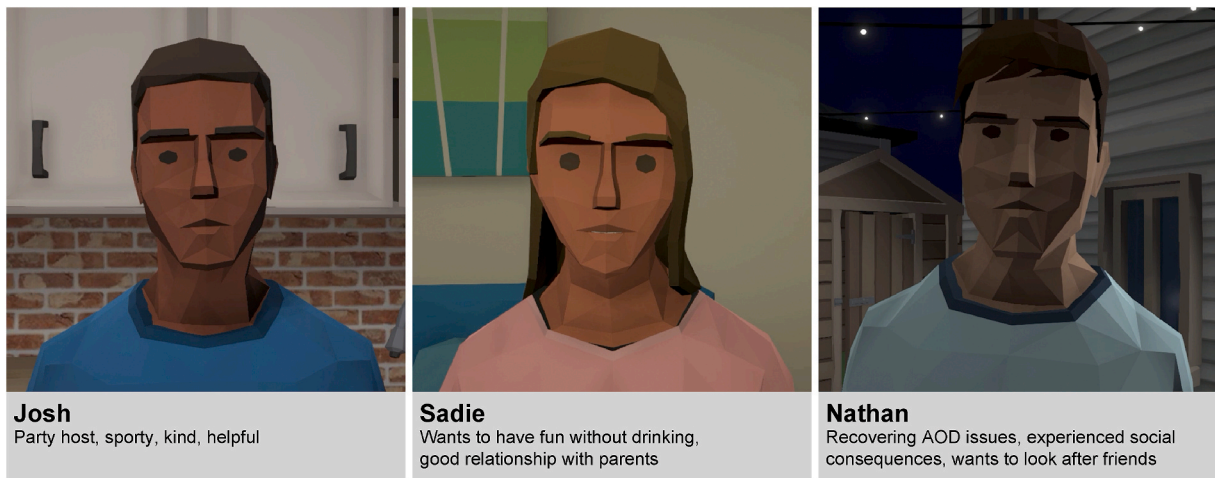


Fig. 4. Sideffect GamePlan main characters.

as a way to learn about alcohol and other drugs?“. This question was adapted from the user version of the Mobile Application Rating Scale (Stoyanov et al., 2016). Similar questions have been used previously in AOD education research to determine if end-users are likely to recommend the game to other potential end-users (Newton et al., 2012; Thornton et al., 2018). For this question participants were asked to respond via a 5-point Likert scale from 1 (not at all) to 5 (definitely). Survey results are presented in Table 6. Overall, participants rated game

acceptability and usability favourably and would recommend the game to others as a way to learn about AOD.

Following user-testing of gameplay and completion of the evaluative surveys, participants then completed a script-read for a larger section of Lesson 1. Participants were instructed to follow different branching pathways and complete an early iteration of a lesson activity. In this activity, participants reviewed a list of harm reduction strategies and identified which characters used each strategy.

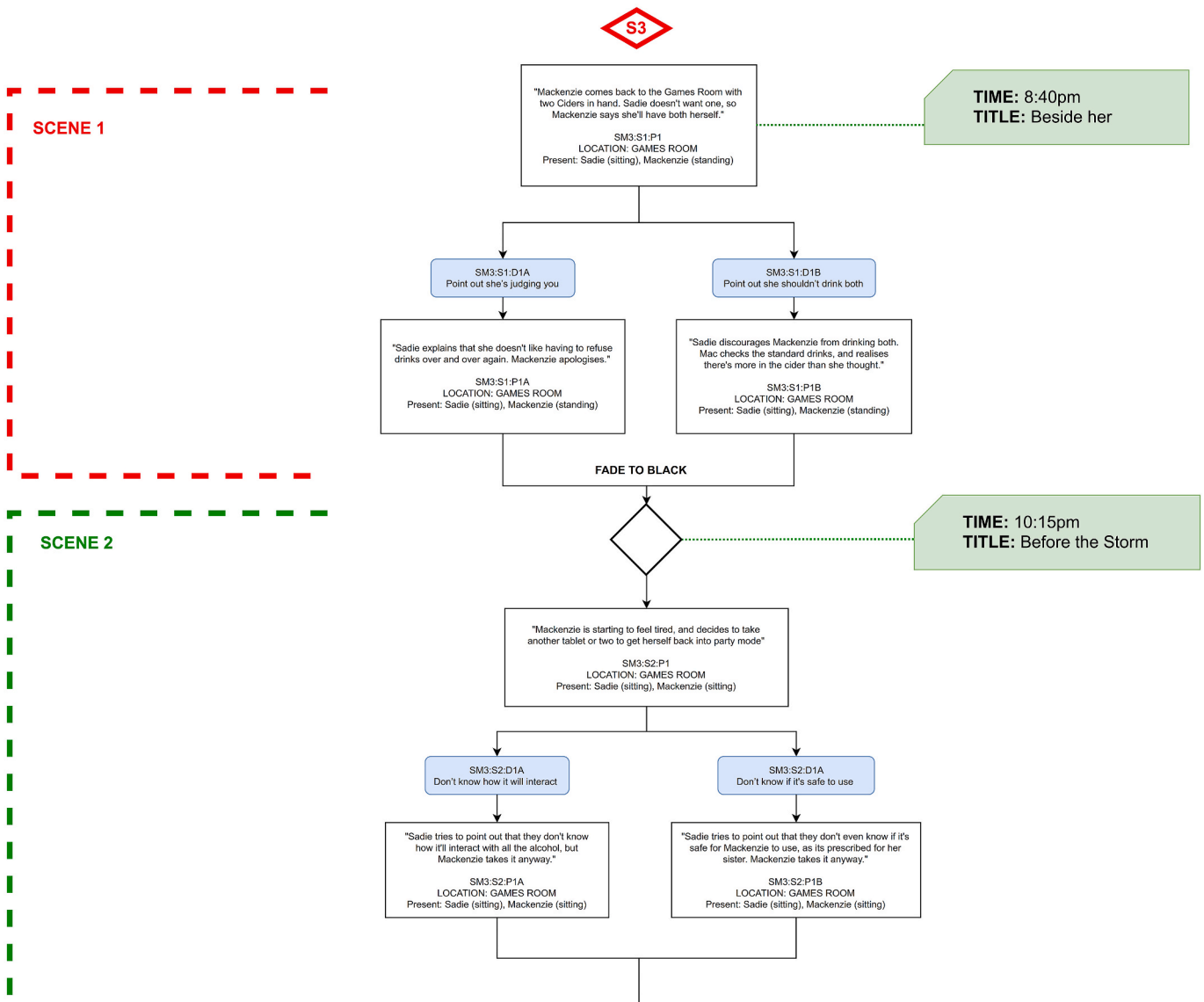


Fig. 5. Example of narrative flowchart depicting scenes and branch points within the game.

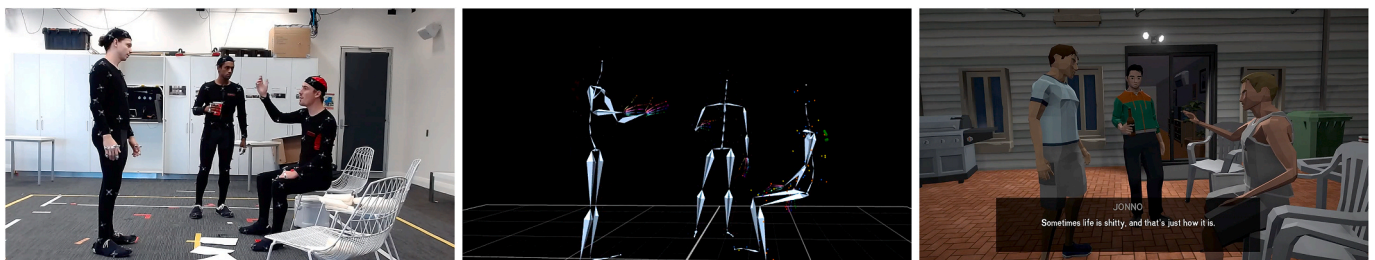


Fig. 6. Motion capture process compilation: (a) motion capture recording session, (b) solving skeletons, and (c) characters in scene from final game.

The final part of the session included focus group discussions targeting user's overall perceptions, with the facilitators guiding discussion to expand on areas of note from the evaluative survey results (e.g., if a low score for game pace was provided, participants were asked to elaborate as to how they felt it might be improved). Discussions covered the following areas: (1) The game itself, including usability, implementation of AOD information, and technical issues (bugs); (2) Narrative elements, such as the relatability and believability of characters, storylines, and language (both for the game-play and scripts); (3) Lesson

content, including the usability, implementation of AOD information, and areas for improvement (both Teacher and Student versions), and; (4) Classroom adoption, with the Teacher's group asked to comment on potential barriers and overall user-friendliness of the game and associated worksheets.

Table 7 outlines focus group feedback from participants along with subsequent changes and considerations implemented into the game and module. Overall, the game aesthetic and storyline were well received by participants. Participants made several recommendations to improve

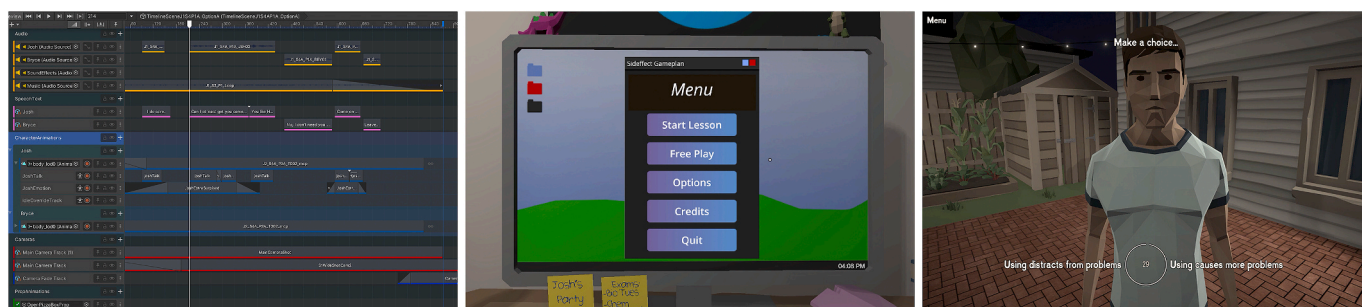


Fig. 7. Digital content compilation: (a) the timeline for a single scene in the *Unity* game engine, (b) the user interface main screen, and (c) final game content scene.

**Table 5**  
Behavioural and psychological theories embedded in the game and module.

Psychological theory	Construct/element	Location in game and module
Theory of Planned Behaviour	Attitudes	Narrative design and multiple storylines used to convey a range of AOD messages, worksheet activities to allow for discussion thereby modifying attitudes towards the harms associated with AOD use and the utility of taking a harm reduction approach to minimising risks. Relatable characters to promote engagement in storylines and underlying AOD messages.
	Perceived behavioural control	Worksheet activities involving planning of harm reduction strategies e.g., planning for harm reduction ahead of a house party, preparing AOD refusal strategies.
	Subjective norms	Modifying social norms through learning in social environment, interactive classroom discussions. Practical AOD refusal skills integrated into game and worksheets, including supporting and respecting friends who wish to choose not to drink alcohol.
Social Cognitive Theory	Cognitive (personal) factors	Improve AOD knowledge, expectations, and attitudes via evidence based AOD content delivered through narrative story and supplemented with worksheets and classroom activities.
	Environmental factors	Setting of game (party) specifically relevant to adolescents and AOD use. Students engage in classroom activities that are build knowledge and skills surrounding AOD social norms, access in the community, influence on others and ability to control environment.
	Behavioural factors	Improve AOD skills and self-efficacy through various experiences (social role models) as per observational learning. Worksheet activities involving planning of harm reduction strategies e.g., planning for harm reduction ahead of a house party, preparing AOD refusal strategies. Characters in the game modelling (observational learning) use of refusal skills and harm reduction strategies, identifying with characters in the game promotes modelling of behaviours.
Self-Determination Theory	Autonomy	Branching mechanics provides decision-making opportunities thereby providing a sense of choice and autonomy.
	Competence	Worksheet activities range from simple (e.g., tick box activity for identifying harm reduction strategies in the game) to more complex (e.g., contextualising harm reduction strategies into planning for own house party).
	Relatedness	Wide range of characters to promote students feeling a sense of relatedness towards a character. No individual character framed as being the 'bad guy', with context given for different behaviours, attitudes, and choices. Resisting social pressure around AOD use, understanding individual needs to feel connected or related to others. Interactive classroom discussions promote conversations between students and sharing of ideas.

reliability of characters and engagement with the game. These included incorporating greater variation in character appearances to improve diversity and changing Josh’s voice to sound less monotone and more enthusiastic. The project team implemented these changes along with fixing small technical issues such as refining character animations. Suggestions to improve elements of the workbook activities and classroom discussions were also made. These changes, along with considerations to promote adoption amongst teachers, were subsequently implemented by the project team (Table 7).

**3. Discussion**

This paper outlines the phases of development of an AOD serious game module entitled *Sideeffect GamePlan* for use by Australian HPE teachers with their students in Years 9 and 10, leveraging a *systematic and iterative user-centred development framework*.

Participants engaged in user-testing viewed the game as engaging and aesthetically pleasing. Students generally commented positively on reliability of characters and relevance of storylines. Suggestions were also made to improve reliability of some characters such as modifying Josh’s voice to be more engaging and increasing diversity in character

appearances. Student engagement has been identified as a key factor contributing to the effectiveness of AOD educational programs (Dusenbury et al., 2003; Meyer & Cahill, 2004), including digital interventions (Stapinski et al., 2018; Vogl et al., 2009, 2012). Hong et al., 2020 reported game enjoyment to be a key feature in contributing to improved drinking refusal self-efficacy and intentions to drink less alcohol in an AOD serious game focused on identifying and reducing risky health behaviours (Hong et al., 2020). Similarly, an entertainment-education video intervention based on SCT and narrative engagement theory reported interest and engagement as important factors contributing to improved AOD refusal self-efficacy and likelihood of use (Shin et al., 2018). Given previous studies have demonstrated a relationship between engagement and AOD-related outcomes, and students in this study reported engaging well with *Sideeffect GamePlan* game elements (in particular characters and storylines) and worksheet activities, *Sideeffect GamePlan* encompasses substantial potential to promote engagement leading to improved AOD-related outcomes. Future research exploring the relationship of engagement with *Sideeffect GamePlan* (as well as other AOD educational and serious games) and AOD learning and behavioural outcomes is recommended.

Lack of suitable resources, outdated information, and teacher

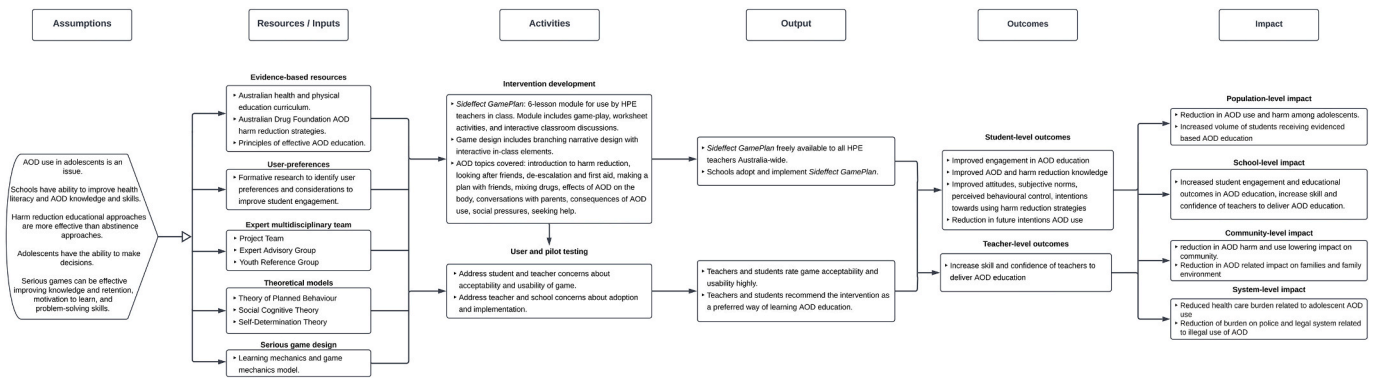


Fig. 8. The logic model of change for Sideffect GamePlan.

confidence have been identified as active barriers to effective drug education among teachers (Stapinski et al., 2017). Teachers in this study rated the game as user-friendly, content to be relevant and appropriate to adolescents, felt confident in delivering the game in class, and would be likely to recommend the game to other teachers. Additionally, in user testing sessions teachers made suggestions to further improve workbook activities to promote usability which were implemented by the project team. Although Sideffect GamePlan was developed with a focus of overcoming barriers of adoption and implementation of AOD education programs by teachers and schools, testing the game and module in a classroom and school setting will be an important next step to gain further insight into adoption and efficacy related outcomes.

Approaches adopted within steps of development were based on serious game and AOD education principles and theories reported to promote learning, engagement, and AOD outcomes. First, Sideffect GamePlan was oriented around interactive teaching strategies (e.g., whole-class interaction leveraging gameplay to promote subsequent classroom discussions), espoused as a highly effective way to develop drug-related knowledge, skills, and attitudes (Meyer & Cahill, 2004). Second, the module focused on harm reduction and protective behaviour strategies. This approach is recommended as AOD experimentation

is normative in young people and decades of research has deemed abstinence approaches (i.e., no substance use, or just resistance skills) ineffective in reducing AOD use and harm (Beck, 1998; Meyer & Cahill, 2004; Midford et al., 2002). Third, Sideffect GamePlan was based on social learning or social cognitive principles. This focus has been effective in reducing AOD use in other internet-based AOD programs (Champion et al., 2013). Further, a review of AOD serious games reports the majority of games targeting increasing knowledge and fostering health behaviour adoption are based on theoretical models. Studies in the review based on elements of SCT or the Theory of Reasoned Action (global theory for TPB (Ajzen, 1991)) report improvements in intentions to drink less and drinking refusal self-efficacy (Hong et al., 2020), likelihood of implementing protective behaviours (e.g., stopping someone they know from driving after drinking alcohol) (Hughes et al., 2016), increased knowledge and decreased intention to use alcohol (Yap et al., 2020), and changes in normative beliefs and attitudes towards prescription misuse (Klisch et al., 2013). Lastly, design features of Sideffect GamePlan align with moderators of learning and retention reported by Wouters et al. (2013) including supplementing gameplay with other instructional methods (i.e., workbooks and classroom discussions), playing the game across multiple lessons (6-lesson module), and

Table 6  
User-testing (2.3 Step 7) survey results: students and teachers.

Item	Students (n = 6) Median (IQR)	Teachers (n = 7) Median (IQR)
1. I found the game engaging	3.50 (2.00–4.25)	3.00 (3.00–4.00)
2. I think the pace of the game is appropriate	3.00 (2.00–4.00)	3.00 (2.00–4.00)
3. I found the graphics appealing	4.00 (2.75–4.25)	3.00 (3.00–4.00)
4. I think the graphics are appropriate	4.00 (3.75–5.00)	3.00 (3.00–4.00)
5. I think the music in the game is engaging	3.50 (2.00–4.00)	3.00 (3.00–4.00)
6. I think the sound effects in the game are engaging	3.00 (2.75–4.25)	3.00 (3.00–4.00)
7. I think the dialogue in the game is engaging	3.50 (2.00–4.25)	4.00 (3.00–4.00)
8. I think the information in the game is informative	2.50 (1.75–3.00)	4.00 (3.00–4.00)
9. I think the information in the game is appropriate for teenagers	3.00 (2.50–5.00)	4.00 (4.00–4.00)
10. I think the content is relevant to high school students	4.00 (1.75–5.00)	3.00 (3.00–4.00)
11. I think the storyline is understandable	3.50 (2.75–4.00)	4.00 (3.00–4.00)
12. I found the alcohol and/or other drug scenarios in the game to be realistic	3.50 (2.50–4.00)	4.00 (3.00–4.00)
13. I think the characters in the game are relatable to teenagers	4.00 (2.50–5.00)	4.00 (2.00–4.00)
14. I think the alcohol and/or other drug harm reduction strategies are believable	2.00 (1.00–3.25)	3.00 (3.00–4.00)
15. I found the game unnecessarily complex	2.00 (1.00–3.25)	1.00 (1.00–2.00)
16. I thought the game was easy to use	5.00 (3.50–5.00)	5.00 (5.00–5.00)
17. I think that I would need the support of a technical person or teacher to be able to use this game	1.00 (1.00–1.00)	1.00 (1.00–1.00)
18. I thought there was too much inconsistency in the game software	1.50 (1.00–2.25)	1.00 (1.00–2.00)
19. I would imagine that most people would learn to use this game very quickly	5.00 (4.75–5.00)	5.00 (5.00–5.00)
20. I found the game very cumbersome to use	1.50 (1.00–2.75)	1.00 (1.00–2.00)
21. I felt very confident using the game	4.00 (4.00–5.00)	5.00 (4.00–5.00)
22. I needed to learn a lot of things before I could get going with the game	1.00 (1.00–1.00)	1.00 (1.00–2.00)
23. I imagine most people would learn from this game	3.00 (1.75–4.25)	3.00 (3.00–4.00)
24. Would you recommend this game to others (e.g., high school teachers or students) as a way to learn about alcohol and other drugs?	3.50 (2.00–4.00)	4.00 (3.00–4.00)



**Table 7**  
User-testing thematic analysis: students and teachers.

Themes	Subthemes	Supporting quotes	Changes and considerations implemented to the game and module
AOD learning	Key AOD learning from game play and worksheets	<p>“I think I just saw on the paper the mixing of drugs as with caffeine and alcohol. I think when students would think of mixing of drugs, they might think of cocaine and meth or something really bad but no. Even something as little as Panadol and alcohol can have a reaction, so I think that was something I learned.” (Student)</p> <p>“I thought it was helpful that some of the people there [characters] didn’t just want to get really drunk. The intention to minimise harm came from people at the party, not an outside source, and especially since it wasn’t just [one] person. People were opting for lemonade.” (Student)</p>	No changes made.
	Suggestions for refining the harm reduction strategy tick box activity in the worksheet to allow for completion alongside the game	<p>“I found sometimes I was having to double check what names were on the table and what weren’t because I’d see someone out that may do a minimisation thing but they aren’t actually on the sheet.” (Teacher)</p> <p>“I like doing it [completing the worksheet] as I went through it [game]. I saw that they did something like that’s just taken off or do a cross if they directly refused something.” (Student)</p> <p>“So when we’re identifying the strategy, some of these kids obviously are not going to remember from year seven what strategies are. Something that can be a first start, as a 10-min who can remember, let’s recap, you can actually build that structure in. So that way, when you go through and then ticking the boxes, they can actually identify what came up because some of the kids probably might miss it even though the information is there.” (Teacher)</p>	<p>The checklist lesson activity, whereby students identified which characters used each harm reduction strategy, was refined and simplified. Stronger focus was placed on identifying relevant strategies and the need to remember individual characters was reduced.</p> <p>Background information on harm reduction was included in workbooks. Activity instructions were also included in teacher guides to allow for pre-framing the activity to students i.e., describing harm reductions strategies to look out for (up to 4 strategies).</p>
	Worksheets reinforce learning	<p>“I think that’s why [a] worksheet is good and easy. They [students] don’t have to write heaps of stuff, so they don’t get lost in it .... If they don’t have a worksheet to go on with it they will just watch – it’s like when you watch a video, if there’s no worksheet with a video, they’ll sit there and look at the screen blankly. But if you pause in the video every 5 min to answer questions, you get to the end, with page notes, that they didn’t even realise they did.” (Teacher)</p>	Worksheets were developed for each of the lessons with a variety of learning activities including, worksheets to complete alongside gameplay, reflections and classroom discussions.
	Suggested classroom activities and discussion points	<p>“[Suggestion to include] strategies people use for not drinking alcohol and they’re saying [for example], ‘I’ve got something on tomorrow’, or ‘I’ve got a driving lesson tomorrow’. Something like that, so that it’s not a yes/no. It’s they’re out and they don’t lose face .... [For classroom activities] give them some ideas and then get their ideas.” (Teacher)</p> <p>“Maybe use some acting [role play] thing. That usually engages kids ... If they don’t want to do it in front of the classroom, you [could do] some little groups.” (Student)</p>	Worksheets were further developed to include activities and classroom discussions for listing and practicing refusal skills, identifying harm and friends in danger, reasons for using harm reduction strategies, and role play.
Relatability, believability, and relevance	Negative (exogenous) consequences from game	<p>“No, I don’t think so. It’s not going to give them any ideas” (Teacher)</p> <p>“As long as you don’t – if they do anything illegal, like smoking a joint or anything, it doesn’t give a positive thing. As long as you stay away from that then, there’s no red flags coming up. Like if you smoke a joint and then had a better time, then you’re like, ‘Oh, perhaps not .... If it’s all negative choices, it’s not going to give them any ideas” (Teacher)</p>	Game content was checked to ensure positive experiences from AOD use were not portrayed.
	Diversity in character personalities and traits, however characters visibly look quite similar	<p>“There’s a good range of characters. Not quite an eclectic group but at least a decent normal group that you’ve got in footy clubs and people that attached to them from school. So it looked like there was an intellectual in there that wanted to have a good time.” (Teacher)</p> <p>“The characters are pretty similar, looking at them.” (Teacher)</p> <p>“I like Bryce’s character because I think that him being the brother and being the awkward one that no one really likes, I think that was a good element, his character and just defies his brother.” (Student)</p>	<p>Existing variations in character skin tones were enhanced to improve clarity.</p> <p>Working within the limitations of the game assets and animation, adjustments were made to character model where possible. For example, jawline, eye and nose sizes, and increase/decrease in torso size where animation would not be impacted.</p>
	Characters appear to be older than school age	<p>“It [the game] had a feel like they [characters] were a bit older than high school age.” (Teacher)</p> <p>“I think if you give a picture from the start that it’s like, no, the high school kids and stuff and that it’s 18 plus, then you can use as a teaching strategy, like once you get to these age, these are the strategies you need to be using, and then they</p>	<p>Information was added to the start of student workbooks to provide context. For example: <i>Josh and his twin brother Bryce are having a party to celebrate the end of exams. Since Josh and Bryce recently turned 18, they were able to buy alcohol for the</i></p>

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Table 7 (continued)

Themes	Subthemes	Supporting quotes	Changes and considerations implemented to the game and module
		can take that from that and realise that they can apply that at a younger age. You're not condoning drinking, this is what you do when you get older." (Teacher)	<i>night, but not all their friends are old enough to drink yet. Their parents are out for the night, and Josh promised to be responsible and keep things under control.</i> <i>Unfortunately, not everything goes according to plan.</i> No changes made.
	Arts style (graphics)	"The graphics were good. I liked the geometric because it made them ambiguous enough to be able to see yourself there, but it didn't de-humanise them. It kind of found a good balance." (S1) "It's pretty snazzy." (Student)	
	Josh's character perceived as lacking emotion and monotone	"He [Josh] just seems to be very concerned over time .... I think if he was a bit more fun, people would be more eager to listen to what he has to say and apply that in their own lives." (Student) "I thought he [Josh] was a bit monotone .... I think it was a bit more of his voice than the character. The character seemed quite believable. I just thought he wasn't as emotional as he could've been." (Teacher)	Voice for Josh was re-recorded with an alternative voice actor to ensure greater diversity in tone and to sound more excited about hosting an end of exams house party.
	Voice and language	"I think that the dialogue used was pretty good. It all felt natural. Like something you would actually expect people to say. Like their human bio exam for example, it's very ... normal." (S1) "Maybe the terminology for some of the students might not [know] – I think there's a word in there, 'hang-ups'. That must be a new term used by teenagers now, that some may be unfamiliar with." (Teacher)	No major changes were made to voice or language other than re-recording Josh voice. Several words or terms were modified to ensure clarity.
Game mechanics	Bugs	"I found every so often, when he's opening up the pizza box or something, his hand would move through it and that ruined the margins." (Student) "[Josh] looked a bit like tipsy, when he was walking over to a few things. It's like he got [on] them now even though Josh was sober." (Student)	Technical issues (bugs) were rectified.
	More text required to describe choices at decision-points	"Just for the decision making, I feel maybe I could give a tiny bit more than just one word for each decision because you can pick one word and it's actually a little bit different to what you thought the character would say I guess. Just to be more clear on what the character is going to say when you pick a dialogue option ... Yeah, defend or complain." (Student)	Text to describe choice options were expanded to include more descriptive words. For example, "defend" was edited to "defend Bryce" and "complain" was edited to "complain about Bryce".
	Game pace too slow	"I think you could also make the timer a little bit shorter." (Student)	The countdown timer at decision branches was reduced to 30 s. A setting was added to the game options to allow adjustment of the timer by intervals of 10, from 20 to 60 s, or turn the timer off altogether.
	Subtitles are useful however ensure synchronised with audio	"I'd keep the subtitles on. It helps you keep track of the story about all it." (Student) "I'd say as well just to make sure that the subtitles keep up with what the voice actors are saying because sometimes it went out of sync, and the voice actors would say something and the subtitles would always switch." (Student)	Synchronisation of audio and subtitles were rectified.
Promoting adoption by teachers	Teacher-led option	"So it might be the case where schools that have limited supply of computers, yeah the teacher is up the front and sort of runs the show, I guess. The class interact, [and say] 'pick that side.'" (Teacher) "If I had to do it, personally, I'd probably do it up the front as opposed to having kids on [the computers] individually, that way you can guide the learning a bit more .... Especially if you wanted to use it for like a main teaching point, like you want to demonstrate a certain idea, or try and get a certain point [across] in terms of the harm minimisation stuff. You direct them down a path that you want, you can go, "This is what they're doing," and you teach it from there, as opposed to just assuming that they've gone down the path you want. So, they're seeing the things that you want them to see as opposed to clicking." (Teacher) "If it's possible to have it [teacher-led] as an option ... At least you'd end up with more discussion, especially if you think of low-literacy kids, they're not going to want to write, so having a discussion is probably a good thing, depending on how big their class is and what sort of class they are." (Teacher)	A teacher-led single-device option was incorporated whereby the game is played on a single device and displayed (such as via a projector) so visible to the entire class. The class votes on which decision to make (at decision branches) throughout the game.
	Flexibility in delivery: select topics within the game rather than by chapter	"Yeah, labelling. Like you said, the sections were labelled, like poor consequence, poorly drug use, then they click on that one that and it goes to that set of choices, or at least potential or right choices. I don't know what you'd	A description of the topics covered in each lesson was added to each of the student workbooks and teacher guides. The option to select a scene in the game (smaller section of one of the three storylines) was also included to allow teachers to replay and focus on a smaller section of the game.

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Table 7 (continued)

Themes	Subthemes	Supporting quotes	Changes and considerations implemented to the game and module
	Module length: suggest 6 weeks of content for 10-lesson program or 10-week term	<p>label. If it was labelling, it could be easy to navigate people will freak out, but if it was just like chapter one, chapter two, chapter three.” (Teacher)</p> <p>“Because they got two [classes] a week, and it’s the ten-week program into five and work through it, and so it’s really efficient for us. I don’t know how you guys [run it], when we did long units, it’s a ten-week unit, the kids will just switch off by week six or seven.” (Teacher)</p> <p>“You could have ten [lessons] available, and then it’ll be up to teacher discretion to fit them in. Generally, it’ll be seven [of content] and then one or two assessment and you miss the other one.” (Teacher)</p>	<p>A 6-week module was developed to allow remaining weeks within a 10-week school term to be available for other activities (e.g., assessments)</p>

opportunities for learners to work in groups (i.e., interactive group discussions) (Wouters et al., 2013).

Beyond the purposeful adoption of evidence-based approaches in the context of AOD education and serious games, this study aligns evidence-based approaches within a *systematic and iterative user-centred framework*. Other key elements of the framework include involving end-users throughout the development process, input from an external advisory panel, outlining learning and game mechanics as well as behavioural and psychological theory constructs incorporated into the game and learning resources, and developing a logic model of change which outlines key intervention ingredients and potential mechanisms of change for measuring the effectiveness of the intervention.

Several limitations of this study are important to note. First, the development of *Sideeffect GamePlan* was specific to an Australian education context and end-users were teachers or students from Australian secondary schools, therefore generalisability of findings to other countries may be limited. Second, when user-testing sessions are facilitated by project teams there is a potential for priming effects to occur. The project team set out to obtain both positive and critical feedback from participants and so to mitigate potential priming effects, team members reinforced the importance of providing constructive feedback at the beginning of user-testing sessions. In *Step 2* (establish user preferences) and *Step 7* (user testing) participants provided both positive and constructive feedback, which was considered and incorporated into subsequent iterations, it is therefore less likely that priming effects occurred. Lastly, the purpose of this study was to outline the development of an AOD serious game. Although we collected some indicative data to demonstrate the applicability of the *systematic and iterative user-centred development framework* to develop an AOD serious game, the participant sample was small, and user-testing was conducted in a controlled computer laboratory setting which limits the ability to draw conclusions from survey data. The next phase of research includes testing *Sideeffect GamePlan* in a simulated classroom environment with a new and larger sample of teachers and students. This final phase will allow for further feedback and modifications prior to piloting within schools. These final stages will allow for measuring efficacy and effectiveness of the module in promoting AOD knowledge and reducing AOD-related harm, along with mechanisms of change such as the role of game engagement in mediating intended outcomes.

**Credit author statement**

Joanna Nicholas: Conceptualisation, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Visualisation, Supervision, Writing – original draft, Writing – review & editing, Brennen Mills: Conceptualisation, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing, Sara Hansen Conceptualisation, Data curation, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing, Stephen J Bright: Conceptualisation, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing, Joseph Scott: Methodology, Writing – review & editing, Imogen Ridout: Formal analysis, Data curation, Visualisation, Writing – original draft, Jess Watson: Conceptualisation, Data curation, Investigation, Methodology, Software, Visualisation, Writing – original draft, Writing – review & editing, Heather Boyd Formal analysis, Writing – review & editing, Luke Brook: Conceptualisation, Methodology, Software, Writing – original draft, Luke Hopper: Conceptualisation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – original draft, Writing – review & editing

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## Declaration of competing interest

Edith Cowan University entered into a research agreement with not-for-profit organisation Sideeffect Australia to undertake novel research and development of a serious game focussing on harm minimisation for alcohol and other drug (AOD) education for Australian high school aged students. The contracted activities involved the collection and analysis of research data and development of the AOD serious game.

## Data availability

Data will be made available on request.

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